

LIFAC Sorbent Injection Desulfurization Demonstration Project

Project completed

Participant

LIFAC–North America (a joint venture partnership between Tampella Power Corporation and ICF Kaiser Engineers, Inc.)

Additional Team Members

ICF Kaiser Engineers, Inc.—cofunder and project manager

Tampella Power Corporation—cofunder

Tampella, Ltd.—technology owner

Richmond Power and Light—cofunder and host utility

Electric Power Research Institute—cofunder

Black Beauty Coal Company—cofunder

State of Indiana—cofunder

Location

Richmond, Wayne County, IN (Richmond Power & Light's Whitewater Valley Station, Unit No. 2)

Technology

LIFAC's sorbent injection process with sulfur capture in a unique, patented vertical activation reactor

Plant Capacity/Production

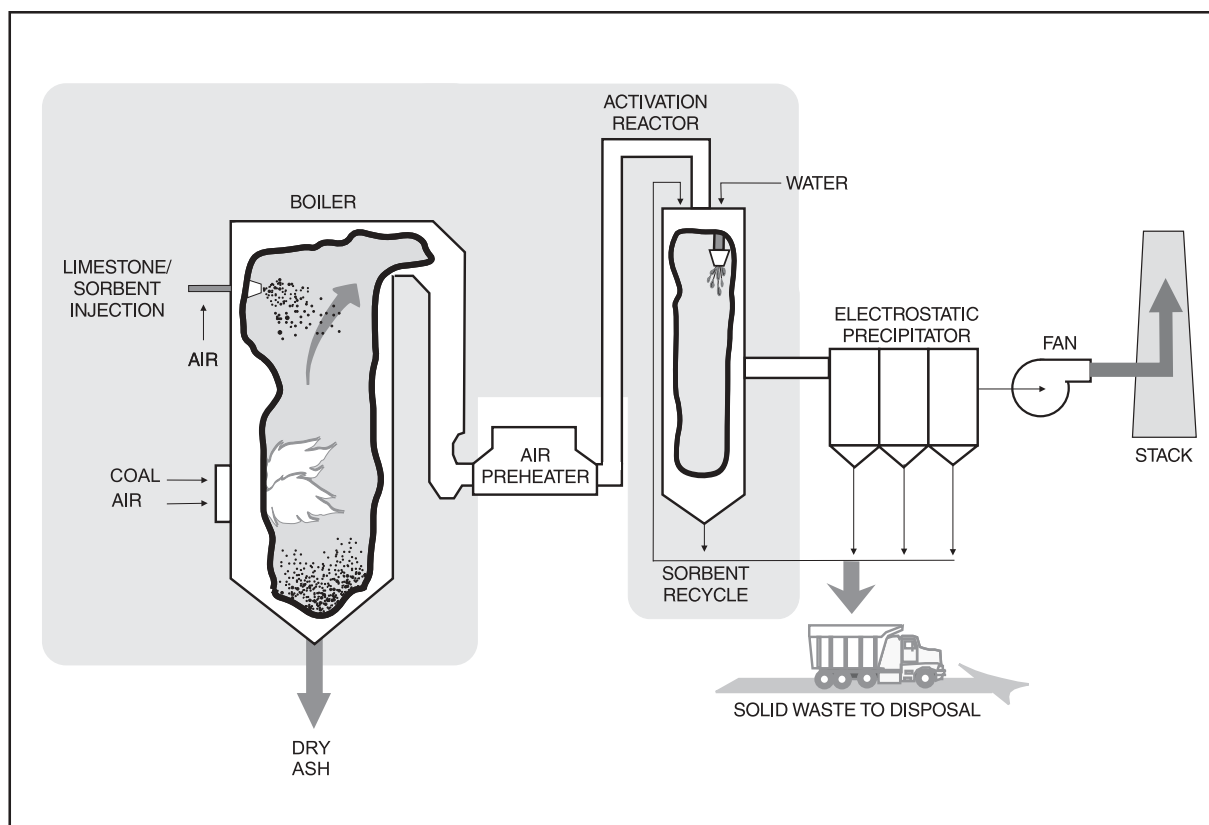
60 MWe

Coal

Bituminous, 2.0–2.8% sulfur

Project Funding

Total project cost	\$21,393,772	100%
DOE	10,636,864	50
Participants	10,756,908	50



Project Objective

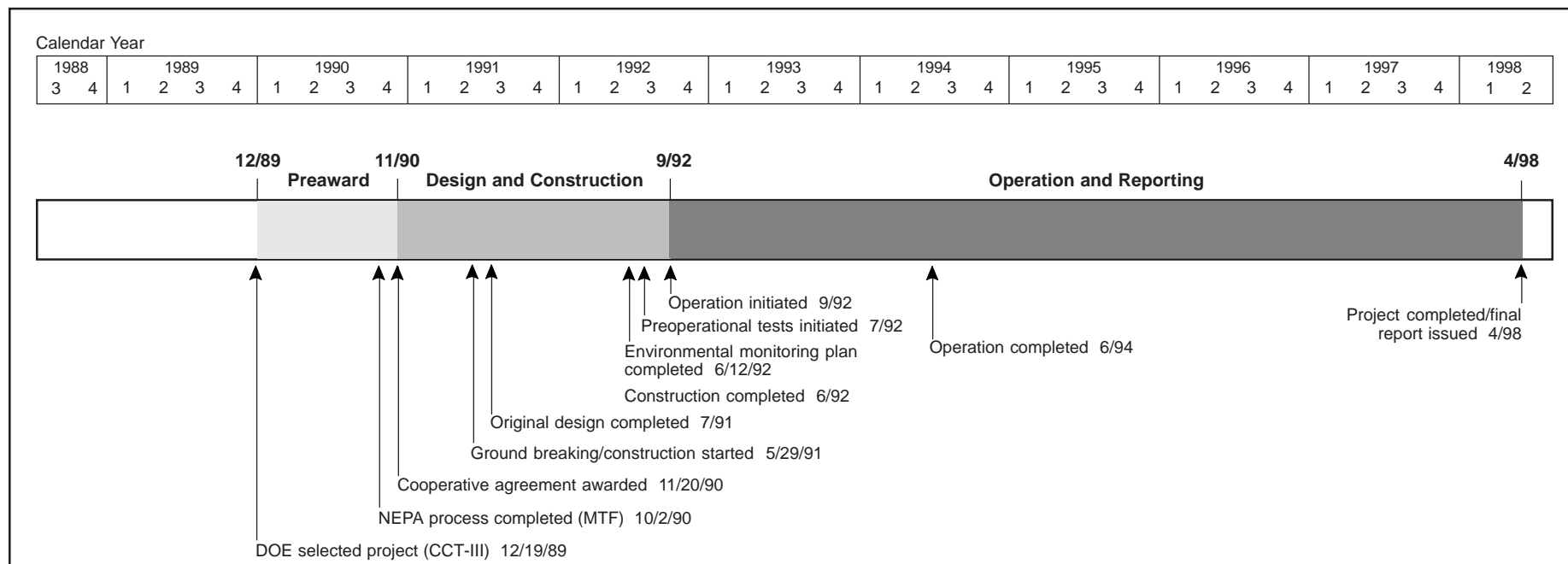
To demonstrate that electric power plants—especially those with space limitations and burning high-sulfur coals—can be retrofitted successfully with the LIFAC limestone injection process to remove 75–85% of the SO₂ from flue gas and produce a dry solid waste product for disposal in a landfill.

Technology/Project Description

Pulverized limestone is pneumatically injected into the upper part of the boiler near the superheater where it absorbs some of the SO₂ in the boiler flue gas. The limestone is calcined into calcium oxide and is available for capture of additional SO₂ downstream in the activation, or humidification, reactor. In the vertical chamber, water sprays initiate a series of chemical reactions leading to SO₂ capture. After leaving the chamber, the sorbent is

easily separated from the flue gas along with the fly ash in the electrostatic precipitator (ESP). The sorbent material from the reactor and electrostatic precipitator are recirculated back through the reactor for increased efficiency. The waste is dry, making it easier to handle than the wet scrubber sludge produced by conventional wet limestone scrubber systems.

The technology enables power plants with space limitations to use high-sulfur midwestern coals, by providing an injection process that removes 75–85% of the SO₂ from flue gas and produces a dry solid waste product suitable for disposal in a landfill.



Results Summary

Environmental

- SO₂ removal efficiency was 70% at a calcium-to-sulfur (Ca/S) molar ratio of 2.0, approach-to-saturation temperature of 7–12 °F, and limestone fineness of 80% minus 325 mesh.
- SO₂ removal efficiency was reduced an additional 15% by increasing limestone fineness to 80% minus 200 mesh and maintaining a Ca/S molar ratio of 2.0 and 7–12 °F approach-to-saturation temperature.
- The four parameters having the greatest influence on sulfur removal efficiency were limestone fineness, Ca/S molar ratio, approach-to-saturation temperature, and ESP ash recycle rate.
- ESP ash recycle rate was limited in the demonstration system configuration. Increasing the recycle rate and sustaining a 5 °F approach-to-saturation temperature were projected to increase SO₂ removal efficiency to 85% at a Ca/S molar ratio of 2.0 and limestone fineness of 80% minus 325 mesh.

- ESP efficiency and operating levels were essentially unaffected by LIFAC during steady-state operation.
- Fly and bottom ash were dry and readily disposed of at a local landfill. The quantity of additional solid waste can be determined by assuming that approximately 4.3 tons of limestone is required to remove 1.0 ton of SO₂.

Operational

- When operating with fine limestone (80% minus 325 mesh), the sootblowing cycle had to be reduced from 6.0–4.5 hours.
- Automated programmable logic and simple design make the LIFAC system easy to operate in startup, shutdown, or normal duty cycles.
- The amount of bottom ash increased slightly, but there was no negative impact on the ash-handling system.

Economic

- Capital cost (1994\$)—\$66/kW for two LIFAC reactors (300 MWe); \$76/kW for one LIFAC reactor (150 MWe); \$99/kW for one LIFAC reactor (65 MWe).

- Operating cost (1994\$)—\$65/ton of SO₂ removed, assuming 75% SO₂ capture, Ca/S molar ratio of 2.0, limestone composed of 95% CaCO₃, and costing \$15/ton.

Project Summary

The LIFAC technology was designed to enhance the effectiveness of dry sorbent injection systems for SO₂ control and to maintain the desirable aspects of low capital cost and compactness for ease of retrofit. Furthermore, limestone was used as the sorbent (about 1/3 of the cost of lime) and a sorbent recycle system was incorporated to reduce operating costs.

The process evaluation test plan was composed of five distinct phases, each having its own objectives. These tests were:

- Baseline tests characterized the operation of the host boiler and associated subsystems prior to LIFAC operations.
- Parametric tests were designed to evaluate the many possible combinations of LIFAC process parameters and their effect on SO₂ removal.
- Optimization tests were performed after the parametric tests to evaluate the reliability and operability of the LIFAC process over short, continuous operating periods.
- Long-term tests were designed to demonstrate LIFAC's performance under commercial operating conditions.
- Post-LIFAC tests involved repeating the baseline test to identify any changes caused by the LIFAC system.

The coals used during the demonstration varied in sulfur content from 1.4–2.8%. However, most of the testing was conducted with the higher (2.0–2.8%) sulfur coals.

Environmental Performance

During the parametric testing phase, the numerous LIFAC process values and their effects on sulfur removal efficiency were evaluated. The four major parameters having the greatest influence on sulfur removal efficiency were limestone fineness, Ca/S molar ratio, reactor bottom temperature (approach-to-saturation), and ESP ash recycling rate. Total SO₂ capture was about 15% better when injecting fine limestone (80% minus 325 mesh) than it was with coarse limestone (80% minus 200 mesh).

While injecting the fine limestone, the sootblowing frequency had to be increased from 6-hour to 4.5-hour cycles. The coarse-quality limestone did not affect soot-

blowing but was found to be more abrasive on the feed and transport hoses.

Parametric tests indicated that a 70% SO₂ reduction was achievable with a Ca/S molar ratio of 2.0. ESP ash containing unspent sorbent and fly ash was recycled from the ESP hoppers back into the reactor inlet duct work. Ash recycling was found to be essential for efficient SO₂ capture. However, the large quantity of ash removed from the LIFAC reactor bottom and the small size of the ESP hoppers limited the ESP ash recycling rate. As a result, the amount of material recycled from the ESP was approximately 70% less than had been anticipated, but even this low recycling rate was found to affect SO₂ capture. During a brief test, it was found that increasing the recycle rate by 50% resulted in a 5% increase in SO₂ removal efficiency. It was estimated that if the reactor bottom ash is recycled along with ESP ash, while sustaining a reactor temperature of 5 °F above saturation temperature, an SO₂ reduction of 85% could be maintained.

Operational Performance

Optimization testing began in March 1994 and was followed by long-term testing in June 1994. The boiler was operated at an average load of 60 MWe during long-term testing, although it fluctuated according to power demand. The LIFAC process automatically adjusted to boiler load changes. A Ca/S molar ratio of 2.0 was selected to attain SO₂ reductions above 70%. Reactor bottom temperature was about 5 °F higher than optimum to avoid ash buildup on the steam reheaters. Atomized water droplet size was smaller than optimum for the same reason. Other key process parameters held constant during the long-term tests included the degree of humidification, grind size of the high-calcium-content limestone, and recycle of spent sorbent from the ESP.

Long-term testing showed that SO₂ reductions of 70% or more can be maintained under normal boiler operating conditions. Stack opacity was low (about 10%) and ESP efficiency was high (99.2%). The amount of boiler bottom ash increased slightly during testing, but there was no negative impact on the power plant's bottom and fly ash removal system. The solid waste generated was a mixture of fly ash and calcium compounds, and was readily disposed of at a local landfill.



The LIFAC system successfully demonstrated at Whitewater Valley Station Unit No. 2 is being retained by Richmond Power & Light for commercial use with high-sulfur coal. There are 10 full-scale LIFAC units in Canada, China, Finland, Russia, and the United States.

The LIFAC system proved to be highly practical because it has few moving parts and is simple to operate. The process can be easily shut down and restarted. The process is automated by a programmable logic system that regulates process control loops, interlocking, startup, shutdown, and data collection. The entire LIFAC process was easily managed via two personal computers located in the host utility's control room.



The top of the LIFAC reactor is shown being lifted into place. During 2,800 hours of operation, long-term testing showed that SO₂ reductions of 70% or more could be sustained under normal boiler operation.

Economic Performance

The economic evaluation indicated that the capital cost of a LIFAC installation is lower than for either a spray dryer or wet scrubber. Capital costs for LIFAC technology vary, depending on unit size and the quantity of reactors needed:

- \$99/kW for one LIFAC reactor at Whitewater Valley Station (65 MWe) (1994\$),

- \$76/kW for one LIFAC reactor at Shand Station (150 MWe), and
- \$66/kW for two LIFAC reactors at Shand Station (300 MWe).

Crushed limestone accounts for about one-half of LIFAC's operating costs. LIFAC requires 4.3 tons of limestone to remove 1.0 ton of SO₂, assuming 75% SO₂ capture, a Ca/S molar ratio of 2.0, and limestone containing 95% CaCO₃. Assuming limestone costs of \$15/ton, LIFAC's operating cost would be \$65/ton of SO₂ removed.

Commercial Applications

There are 10 full-scale LIFAC units in operation in Canada, China, Finland, Russia, and the United States. The LIFAC system at Richmond Power & Light is the first to be applied to a power plant using high-sulfur (2.0–2.9%) coal. The LIFAC system is being retained by Richmond Power & Light at Whitewater Valley Station, Unit No. 2. The other LIFAC installations on power plants are using bituminous and lignite coals having lower sulfur contents (0.6–1.5%).

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